AIR RESOURCES BOARD

BOARD MEMBERS' ADVANCE AGENDA

Meeting of the Research Screening Committee

Air Resources Board
Research Division
First Floor Conference Room
2020 L Street
Sacramento, CA 95814
(916) 445-0753

May 26, 2000
9:00 a.m.

REQUEST FOR PROPOSALS

1. "Improvement of Emissions Inventories for Industrial Coatings and Thinning and Cleanup Solvents," RFP No. 00-3

According to the estimates based on the existing data, industrial coatings and their thinning and cleanup solvents contributed 103 tons of total organic gas (TOG) emissions per day in California in 1995. Solvents used for the thinning and cleaning-up of architectural coatings contributed another 23 tons of TOG emissions per day. However, these estimates are based on data gathered in 1980 to 1982. Changes in coating formulations and application methods (e.g., the introduction of water-based coatings) since that time have invalidated the old database. The proposed project would conduct comprehensive surveys of manufacturers, distributors, and users to obtain current data on the compositions, volumes, and methods of application for both coatings and solvents. This study will update the emissions inventories for industrial coatings, solvents used for the thinning and cleanup of industrial coatings, and solvents used for the thinning and cleanup of architectural coatings.

INTERAGENCY PROPOSALS

2. "Economic Value of Hospitalizations Associated with Particulate and Ozone Air Pollution," San Diego State University, $249,230, Proposal No. 2451-214

The ARB's primary role is to protect public health by reducing air pollutants through regulatory actions. Currently, the proposed regulations are generally analyzed in terms of the cost and cost effectiveness. However, some board members have expressed concerns over the lack of information on the economic

value of health benefits when making regulatory decisions. This study will develop comprehensive cost-of-illness (COI) and willingness-to-pay (WTP) estimates for the economic value of hospitalizations and doctor visits that have been linked to particulate matter and ozone air pollution exposures.

Drs. Laurie Chestnut and Bob Rowe of Stratus Consulting, experts in WTP survey design, would be responsible for developing WTP survey and conducting corresponding analysis. Kaiser Permanente would be responsible for obtaining and completing preliminary analysis of the COI data, implementing the WTP survey, and analyzing the preliminary survey results. Results from this study will extend both the empirical and methodological basis for economic benefit valuation of air quality control measures and will increase the ARB's ability to assess the benefits of particulate and ozone exposure.

3. "Determination of the Contributions of Light-Duty and Heavy-Duty Vehicle Emissions to Ambient Particles in California," University of California, Riverside, $200,653, Proposal No. 2452-214

To attain the National Ambient Air Quality Standards for particulate matter (PM), California needs to develop controls to reduce ambient concentrations of aerosols. Developing a scientific foundation for future PM controls requires research on three fronts: 1) to characterize directly emitted "primary" aerosols in sufficient detail to link them to particular sources; 2) to study the dynamics of particle aging in ambient air; and 3) to investigate "secondary" particle formation from gaseous precursors in direct gas-to-particle, droplet, and condensation processes. Previous work with Aerosol Time of Flight Mass Spectrometry (ATOFMS) has demonstrated that ATOFMS can overcome many of the limitations of conventional aerosol analysis. It provides real-time data, eliminating problems of long-time sample integration, lags between sample collection and data availability, and positive and negative chemical artifacts. It also provides unprecedented specificity regarding particle size and composition within a heterogeneous mix of particles in ambient air. The tasks in this proposal will address certain open issues regarding the sampling of motor vehicle aerosols in both controlled (dyno testing) and ambient settings, and will then apply the refined motor vehicle aerosol profiles to the analysis of data collected during previous field studies.

4. "Studies of the Atmospheric Chemistry of Volatile Organic Compounds and of their Atmospheric Reaction Products," University of California, Riverside, $300,000, Proposal No. 2453-214

Large quantities of volatile organic compounds (VOCs) are emitted into the atmosphere from anthropogenic sources. In the atmosphere, these VOCs can react with hydroxyl (OH) radicals, nitrate ion (NO_3) radicals, and ozone (O_3), or can undergo photolysis. VOCs and their subsequent products can lead to the

formation of ozone secondary organic aerosol and toxic air contaminants, resulting in adverse effects on human health and visibility. To understand the effect of an emitted compound on air quality, it is necessary to have information about not only the parent compounds, but also the first- and later-generation products.

This project will investigate the atmospherically important reactions of selected VOCs. It will address the critical gaps in our understanding of the chemistry of compounds important in the formation of ozone, such as aromatic compounds, carbonyls, and multifunctional carbonyls. Carbonyl and multifunctional carbonyls are also believed to influence the production of secondary organic aerosols. Another area of investigation will be the formation of nitro-polycyclic aromatic hydrocarbons (PAHs). PAHs, such as naphthalene and biphenyl, can be transformed in the atmosphere to nitro-PAHs, compounds that tend to be more carcinogenic than unsubstituted PAHs. This project will investigate the formation of nitro-PAH as a function of the NO_2 concentration. Lastly, it will investigate the products formed from the gas-phase photoxidation of PAHs present in diesel fuel. The information gained in this project will improve our understanding of the processes involved in the formation of pollutants that pose health risks and degrade California's visibility.

FINAL REPORTS

5. "Energy Efficient Ultra-Low NO_x Industrial Gas Burners," University of California, Irvine, $225,000, Contract No. 95-310

The State Implementation Plan requires significant reductions in nitrogen oxide (NO_x) emissions. This study developed and demonstrated technologies for the energy-efficient operation of natural gas burners, with an emissions target of single-digit part-per-million (ppm) nitric oxide (NO) levels. Emissions of carbon monoxide, total hydrocarbon, and air toxics were minimized. The technologies developed included: 1) optical diagnostic techniques to measure temperature and species in the burner flame; 2) a numerical code to incorporate a mixing model and chemical kinetic models; 3) active control methods to achieve ultra-low-NO_x performance in practical systems; and 4) robust sensors for these active control methods. The usual technologies to achieve very low levels of NO_x from combustion sources, such as selective catalytic reduction and selective non-catalytic reduction, are very expensive. Industry will be able to use the results of this study to develop cheaper technologies to achieve similar levels of NO_x reduction from natural-gas-fired boilers.

6. "The Assessment of the Effectiveness of Room Enclosures with Ventilation Systems in Reducing Risk at Dry Cleaning Facilities Using Perchloroethylene," AVES, An Affiliate of ATC Associates, Inc., $130,477, Contract No. 96-324

Perchloroethylene (perc) is a toxic air contaminant and human carcinogen. It is the solvent used by the great majority of dry cleaners and the dry cleaning industry is the largest user of perc in California. California's Health and Safety Code requires that a facility identified as posing a "significant risk" to the public by an air pollution control district or air quality management district must develop and implement a plan to reduce its risk below the significant risk level set by that district. One of the risk reduction measures identified by the California Air Pollution Control Officers Association dry cleaning workgroup is the use of room enclosures with ventilation systems.

In this study, the contractor obtained data on and documented the effectiveness of room enclosures with ventilation systems in reducing risk to the public at dry cleaning facilities that use perc. The contractor also developed guidelines for the dry cleaning industry on room enclosure design, installation, operation, and risk reduction potential. The resulting information may help the dry cleaning industry reduce the risk of public exposure to perc emitted from their facilities.

7. "The Health Impact of Nitric Oxide: Effects on Lung Function, Cellular and Biochemical Processes in Healthy Humans," University of California, San Francisco, $32,880, Contract No. 97-329

Nitric oxide (NO) is produced during combustion and is commonly found in urban atmospheres, as well as indoor environments, throughout California. Although it normally converts to nitrogen dioxide (NO_2) quite readily, NO is found in significant concentrations in ambient urban air near combustion sources, and especially near major highways. Recent epidemiologic studies suggest a link between NO_2 exposure and childhood respiratory infection, lung cell damage, croup, asthma, bronchitis, and adverse changes in immune system functions. But NO_2, under controlled exposure conditions, has not been shown to be harmful. This raises the question as to whether the observed epidemiologic effects may in fact be due to the precursor, NO. Recent research has also indicated that NO is produced endogenously by a variety of cell types, including smooth muscle cells, airway epithelial cells, platelets, nerves, macrophages, and other immune system cells. Research has also shown that NO can regulate the function of many cells, including (but not limited to) immune system cells, platelets, and nerves.

The specific objectives of this project were: 1) to review the basic scientific, clinical, and epidemiologic literature relating to NO; 2) to assess the effects of ambient levels of NO on humans; and 3) to evaluate the potential for ambient NO to cause or worsen human disease. The results of the project include a bibliography of scientific publications, summary of the information contained in those publications, and data on indoor NO concentrations in a hospital laboratory.

8. "Determination of the Horizontal Diffusion Coefficient for Use in the SARMAP Air Quality Model," Earth Tech, Inc., $94,352, Contract No. 96-314

Estimates of peak ozone concentrations by air quality models, used by regulators to develop air pollution control plans, have often been significantly lower than measured values. A number of factors may be responsible for this under-prediction of peak ozone concentrations, including non-physical factors such as the numerical procedures used to solve the complex mathematical equations within the model. In this study, the investigators determined the magnitude of the horizontal diffusion coefficient under various conditions, using both theoretical formulations and experimental results. The numerical diffusion associated with the three-advection schemes of interest (Bott, Yamartino, and Accurate Space Derivative) was quantified. Various versions of SARMAP Air Quality Model (SAQM) were then exercised on the August 3-6 San Joaquin Valley Air Quality Study (SJVAQS) ozone episode to evaluate the sensitivity of SAQM to the various computing modules added during this study and to compare the model results, using the three different advection schemes. These runs demonstrated that the SAQM code modifications, designed to make the treatment of diffusion in SAQM more physically realistic, were properly integrated into the current operational version of the modeling system, resulting in improved model performance and accuracy of the resulting control strategy simulations.

9. "Aircraft Sampling to Determine Atmospheric Concentrations and Size Distributions of Particulate Matter and other Pollutants over the South Coast Air Basin," California Institute of Technology, $199,663, Contract No. 96-315

Mathematical air pollution models play an important role in the assessment of the impacts of proposed air pollution control strategies. Those models require three-dimensional inputs of air quality, meteorology, and emissions data. Surface monitoring networks offer an indication of the horizontal variability of the pollutant distribution. However, they cannot provide information on the vertical structure, which is necessary for determination of, among other things, concentrations of pollutants that may have been left over from the previous day.

Such information is critical to accurate model representation of air pollution sources, transformation, and transport.

In this study, part of the 1997 Southern California Ozone Study (SCOS97), 12 flights were conducted with an aircraft instrumented to characterize the chemical and physical properties of aerosols in the Los Angeles basin. Collectively, the data obtained in this sampling program provide further insight into microphysical processes that govern the size, composition, and spatial and temporal behavior of aerosols in the Los Angeles basin. Coupled with the vast database collected during SCOS97, these data will facilitate development of increasingly powerful atmospheric models.

10. "Investigation of Atmospheric Reactivities of Selected Consumer Product VOCs," University of California, Riverside/CE-CERT, $229,754, Contract No. 95-308 and $106,699, Contract No. 92-329

Volatile organic compounds (VOCs) react in the atmosphere to produce different amounts of ozone. This ozone-forming potential is called reactivity. Control strategies that take reactivity into account, rather than treat all VOCs equally, can potentially achieve ozone reductions in a more cost-effective manner. The ARB is currently developing amendments to the California Low Emissions and Reactivity (CLEAR) regulation, which would establish reactivity-based limits for aerosol coatings. In support of this regulation, this project investigated the reactivities of several compounds which industry believes are important to the consumer products inventory.

Environmental chamber experiments were conducted to measure the effect of the selected compounds on ozone formation. The results were then used to derive the chemical mechanisms necessary to quantify reactivity. Additionally, because it is necessary to consider the uncertainty associated with an estimate of reactivity when designing a regulation, this report also provides a quantification of the uncertainty associated with each reactivity value.

As part of this contract, Dr. Carter has written SAPRC99, the chemical mechanism used to calculate reactivity values for ARB regulations. Dr. Carter updated a previous version of the SAPRC chemical mechanism by improving the base mechanism, updating the kinetic parameters to reflect the most recent literature, adding classes of VOCs which are important for the consumer products inventory, and performing experiments and computer modeling to determine their reactivity and deduce their chemical mechanisms. A condensed version of the mechanism was developed for use in regional models.

11. "Improvement of Speciation Profiles for Aerosol Coatings," California Polytechnic State University, $28,885, Contract No. 98-306

ARB's emissions inventory is an estimate of the amount of pollutants emitted into the atmosphere from major source categories. While some emissions may consist of a single compound, many sources emit complex mixtures. These are represented in the emission inventory by speciation profiles. Speciation profiles provide the detailed chemical composition needed for modeling, attainment planning, and regulatory strategies. Speciation profiles are also increasingly used in source apportionment and source reconciliation studies and to estimate toxic emissions. Aerosol coatings produce a large portion of the emissions in the consumer product category, and better data concerning the identity and quantity of the organic species in these products is needed to determine their ozone-forming potential. Identifying the different chemical species in consumer products is also important for the ARB's Toxic Air Contaminant Control and Air Toxics "Hot Spot" programs.

This study determined the chemical speciation profiles of approximately 40 aerosol coating products and combined the individual profiles with speciation profiles determined in an earlier contract to produce group profiles. These group profiles will provide supplementary information for ARB's emissions inventory. This project has improved ARB's hydrocarbon and air toxics emissions inventory and the resulting data will assist in the development of improved mid- and long-term consumer product control measures.

12. "Review and Improvement of Methods for Estimating Rates of Photolysis in Photochemical Models," University of California, Berkeley, $182,302, Contract No. 96-335

Decision-makers rely on results from air quality models, specifically the predicted response in ozone concentrations resulting from changes in emissions of ozone precursors. This information is used to prepare the State Implementation Plan for attaining the federal air quality standard for ozone. Air quality models quantify the processes that control air pollutant concentrations for urban or regional areas. Photolysis, the decomposition (or photodissociation) of chemical compounds by light, is an important step in the series of chemical reactions that form ozone. Specific wavelengths of the radiation in sunlight decompose (photolyze or photodissociate) specific chemical compounds in the atmosphere. Because these compounds and the products of their decomposition participate in the chemical reactions that form ozone, rates of photolysis influence the rate of ozone formation in the atmosphere and likewise, estimated rates of photolysis help to determine the ozone concentrations predicted by air quality models.

The completed work provides a radiative transfer model suitable for use with existing regulatory air quality models to supply better estimates of the rates of photolysis. Application of this new tool is expected to improve the treatment of chemistry in air quality models and thereby improve the quality of information

available to decision-makers regarding how ambient ozone concentrations will change in response to changes in emissions.

13. "Improving the Accuracy of Mixing Depth Predictions from the Mesoscale Meteorological Model MM5," MCNC-Environmental Programs, $92,481, Contract No. 96-319

Accurate meteorological information is needed to support air quality modeling, which is used to predict future air quality, determine the effects from control of emissions, and formulate the State implementation plans for attaining federal standards for ozone and particulate matter. Ambient pollutant concentrations are sensitive to the mixing depth -- the depth in the atmosphere through which pollutants emitted near the surface are mixed and diluted. Therefore, this depth must be correctly characterized for reliable air quality modeling results. Meteorological models that both simulate the thermodynamics of the atmosphere and utilize meteorological observations can better characterize the spatial and temporal variability of mixing depth, winds, and other variables needed in the air quality model, compared to what could be done using diagnostic modeling of the observations.

The objective of this study was to improve the accuracy of the mixing depth estimates generated by the meteorological, state-of-the-science model widely known as MM5 and used by the ARB. It simulates the physical processes and assimilates information from meteorological measurements. MM5 was demonstrated, in developing the State Implementation Plan for Ozone, to reproduce the significant flow features in areas of complex terrain with finer detail than would be expected from the spacing of the available observations. However, MM5 overestimated the mixing depth when used with limited observations. The contractors have investigated the numerical and physical processes in the model that affect estimation of mixing depth. They have tested and described improvements in the formulation of MM5, the handling of input data, and practices regarding model application. Application of these findings will increase the accuracy of mixing depth estimates used in the air quality models.

14. "Air Quality Impacts Associated With Economic Market Potential for Distributed Generation in California," Distributed Utility Associates, $98,960, Contract No. 97-326

This study estimated the economic market potential of cost-effective distributed generation (DG) in California. The DG sources investigated were small electricity generators that use hydrocarbon-based fuels to produce electricity and range from 50 kilowatts to 5 megawatts in generation capacity. Air emissions from each cost-effective distributed generator were then calculated, based on cost-effective hours of operation and the size of the generator. These

results were compared to the air emissions that would have resulted from central power generation only, to determine the net and relative emission impacts for each distributed generator. Air emissions calculated included NO_x, SO_x, CO, CO_2, VOCs, and PM10.

Overall, the study found that the increased use of combustion-based distributed generators would increase all emissions except SO_x, when compared to the existing mix of in-state generation. However, some distributed generators are nearly as clean as, or even cleaner than, new central generation. The study also found that the economic market potential for DG, even for cost-effective applications, is likely to be modest for the next few years. This is due to a wide range of factors, such as unfamiliarity with the technologies, the reluctance of regulators to allow “wires” utilities to own and operate distributed generators, and local air quality regulations. The use of DG, however, will increase slowly as the obstacles are overcome and distributed generator technologies’ cost and performance improves.